# Environmental assessment of olive pomace valorisation through combustion processes for energy production

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There is unequivocal evidence that there are many environmental problems that represent a serious threat to our planet, such as climate change, acidification, eutrophication and negative effects on human health. Population growth is a major problem that leads to a greater amount of resources (materials and energy) and environmental degradation (Patten, 2014). In addition, the use of fossil fuels produces greenhouse gas emissions, which are responsible for global warming and implicitly climate change (Rahman and Miah, 2017). To reduce those environmental problems, a series of measures must be taken, including energy efficiency, underground carbon sequestration and the use of non-fossil fuel sources (Houghton, 2009).

In recent years, biomass has shown great potential as a source of renewable energy. The main advantages of biomass are that it is available in large quantities at a relatively low cost and biomass energy produces less carbon and fewer greenhouse gases than energy from fossil fuels (Borrion et al., 2012). Energy from biomass can be directly obtained by combustion or indirectly obtained through products that can be assimilated to fuels derived from coal and oil (Arena et al., 2015). The olive pomace is an important by-product of the olive oil extraction and it is considered a suitable candidate as a renewable feedstock. To determine the environmental performance related to the energy production from olive pomace, a life cycle assessment (LCA) must be performed.

The main goal of this study is to evaluate the performance associated with the energy production through combustion process of olive pomace. In this regard, the different steps involved in the olive pomace valorization chain are analyzed: olives production, olive oil extraction (olive pomace generation) and olive pomace combustion. Additionally, the environmental impact analysis performed for each equipment involved in combustion process (crusher, combustor, cyclone, and Rankine cycle) were also evaluated. Figure 1 shows the Aspen Plus® flowsheet simulation for olive pomace combustion process.

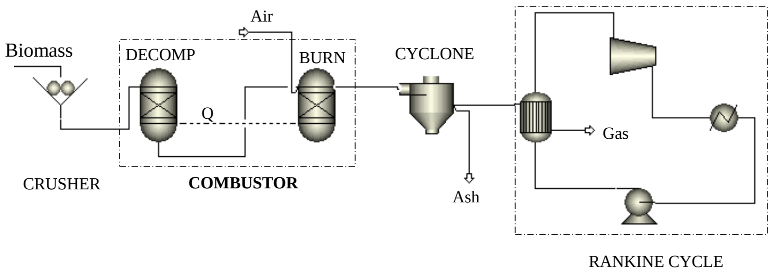


Figure 1: Aspen Plus® flowsheet simulation for combustion process

In this study, the LCA was carried out using the SimaPro 8.2 software, using as a functional unit 1 MJ energy produced. The ReCiPe Mid-point were used to determine the environmental performance associated with the energy production and the following mid-point impacts category were selected: climate change (CC), ozone depletion (OD), terrestrial acidification (TA), freshwater eutrophication (FE), marine eutrophication (ME), human toxicity (HT), photochemical oxidant formation (POF), particulate matter formation (PMF), water depletion (WD) and fossil depletion (FD). The economical allocation for the olive pomace as a co-product was used. In this study, the input and output data for the olive production, olive oil extraction, and combustion process were obtained from an olive mill plant *Aceites García de la Cruz* located in Castilla-La Mancha (Toledo, Spain), Ecoinvent 3.4 database and Aspen Plus® 8.8 software, respectively.

Figure 2 shows that the olive oil extraction stage has the highest impact in almost all the assessed categories, followed by olive production and the combustion process. This fact is mainly related to the energy and diesel consumption and the emissions released. A different trend is observed for the case of the HT and POF categories. In this case, the combustion process is the one that more affects them, mainly due to the ash and emissions generated. The emissions could play an important role in different impact categories (Wagner and Lewandowski, 2017). In case of the olive oil extraction and combustion processes stages, the high energy demand contributes significantly to most of the impact categories evaluated. For a better understanding of the impact generated in the combustion process, the values of the mid-point categories were obtained for each equipment involved in this process (Table 1). RANKINE CYCLE is the major contributor in all impact categories assessed due to the released gases and the energy required for the water pump operation. On the other hand, the CRUSHER equipment had impact values quite similar to those of the COMBUSTOR and CYCLONE equipment for almost all the impact categories. In the case of HT impact it was observed that the CYCLONE presented a higher impact which could be due to the ash generation.

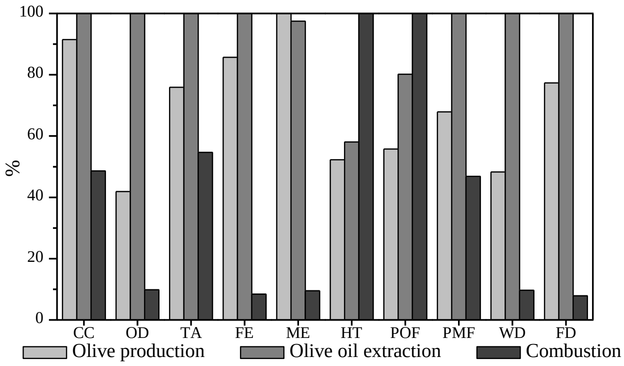


Figure 2: Environmental impact for olive production, olive oil extraction and combustion process

Table 1. Impact assessment results of combustion process taking into account all the equipment used

| | Unit | **Crusher** | **Combustor** | **Cyclone** | **Rankine cycle** |
|---|---|---|---|---|---|
| **CC** | kg CO2 eq | 2,79E-02 | 2,81E-02 | 3,07E-02 | 6,25E-01 |
| **OD** | kg CFC-11 eq | 1,52E-09 | 1,53E-09 | 1,91E-09 | 2,01E-09 |
| **TA** | kg SO2 eq | 7,79E-05 | 7,87E-05 | 9,21E-05 | 1,86E-03 |
| **FE** | kg P eq | 1,67E-06 | 1,68E-06 | 1,89E-06 | 1,95E-06 |
| **ME** | kg N eq | 4,17E-05 | 4,21E-05 | 4,26E-05 | 4,28E-05 |
| **HT** | kg 1,4-DB eq | 1,06E-03 | 1,07E-03 | 4,42E-02 | 4,43E-02 |
| **POF** | kg NMVOC | 3,95E-05 | 3,99E-05 | 4,75E-05 | 2,29E-03 |
| **PMF** | kg PM10 eq | 1,95E-05 | 1,97E-05 | 2,38E-05 | 3,78E-04 |
| **WD** | m3 | 4,59E-05 | 4,63E-05 | 5,72E-05 | 6,00E-05 |
| **FD** | kg oil eq | 1,11E-02 | 1,12E-02 | 1,19E-02 | 1,21E-02 |

In order to improve the environmental performance, some alternatives can be found to reduce the environmental impacts. In the case of agricultural practices, more environmentally friendly fertilizers can be used and, in the case of the combustion process, the efficiencies of the equipment can be improved, the energy amount needed can be reduced and the production of energy can be increased. From the point of view of the generation of energy and the environment, the valorization of olive pomace through the combustion process is an adequate option to produce energy.


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**References**


Arena, U., Ardolino, F., Di Gregorio, F., 2015. A life cycle assessment of environmental performances of two combustion- and gasification-based waste-to-energy technologies. Waste Manage. (Oxford) 41, 60-74.

Borrion, A.L., McManus, M.C., Hammond, G.P., 2012. Environmental life cycle assessment of lignocellulosic conversion to ethanol: A review. Renew Sust Eenerg Rev 16, 4638-4650.

Houghton, J., 2009. Global Warming: The Complete Briefing, 4 ed. Cambridge University Press, Cambridge.

ISO14044, 2006. ISO 14044: Environmental Management, Life Cycle Assessment, Requirements, and Guidelines. International Standard Organization.Patten, B.C., 2014. Systems ecology and environmentalism: Getting the science right. Part I: Facets for a more holistic Nature Book of ecology. Ecol. Model. 293, 4-21.

Rahman, S.M., Miah, M.D., 2017. The impact of sources of energy production on globalization: Evidence from panel data analysis. Renew Sust Eenerg Rev 74, 110-115.

Wagner, M., Lewandowski, I., 2017. Relevance of environmental impact categories for perennial biomass production. GCB Bioenergy 9, 215-228.